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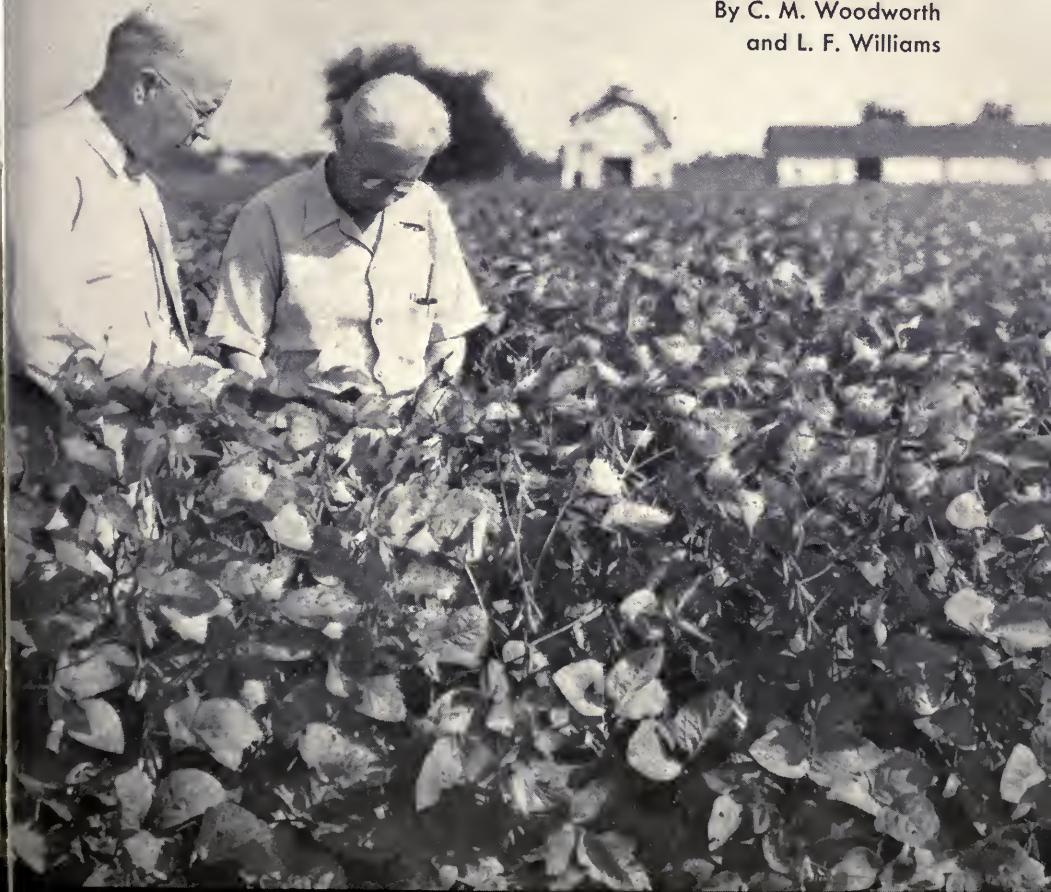
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LINCOLN

A MIDSEASON SOYBEAN For the North-Central States

By C. M. Woodworth
and L. F. Williams



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In cooperation with Bureau of Plant Industry, Soils and
Agricultural Engineering, U. S. Department of Agriculture

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FRONT COVER

Photograph shows an increase plot of Lincoln soybeans on the Agronomy south farm of the University of Illinois. Dr. Woodworth and Dr. W. L. Burlison are inspecting the beans.

LINCOLN: A Midseason Soybean for the North-Central States

By C. M. WOODWORTH and L. F. WILLIAMS

LINCOLN is the most promising midseason variety of soybean developed to date. It is outstanding in yielding ability, percentage of oil, and seed quality, and is above average in resistance to lodging. Because it is adapted to a wide range of soils and climate, it should occupy a large part of the soybean acreage in the North-Central states.

Plant and Seed Characteristics

The Lincoln plant has brown pubescence (soft, short hairs on surfaces of leaves and stems). The flowers are white. In growth habit it is "indeterminate," that is, the stem is terminated by one pod rather than by a cluster of pods. The seeds are round and yellow with a prominent black hilum, or eye. Both plant and seed closely resemble the Manchu variety and a number of Manchu selections. In field appearance, height, lodging resistance, time of maturity, and number of seeds per pod, Lincoln most closely resembles Mandell. The white flowers, however, distinguish Lincoln from Mandell and other commonly grown varieties with brown pubescence.

Lincoln increase field on Agronomy south farm at the University of Illinois. Pods are well set and seeds are developing. Plants are about 36 inches high (stake is marked with 1-foot sections). (Fig. 1)



Since Lincoln is so similar in appearance to Manchu, Mandell, Mingo, Harman, Scioto, and other Manchu selections it is not advisable to grow Lincoln for seed on the same farm with any of these varieties. When there is any doubt as to the identity of seed lots, however, Lincoln can be distinguished by germinating the seed. The hypocotyl, or neck, of the Lincoln seedling, like that of other white-flowered varieties, is green as it emerges from the ground. Manchu strains and other purple-flowered varieties have purple hypocotyls.

Varieties commonly grown have the following characteristics:

<i>Variety^a</i>	<i>Pubescence color</i>	<i>Flower color</i>	<i>Hilum color</i>
Earlyana.....	Brown	Purple	Colorless ^b
Wisconsin Manchu 606.....	Brown	Purple	Black
Wisconsin Manchu 3.....	Brown	Purple	Black
Richland.....	Gray	Purple	Pale slate
Mukden.....	Gray	White	Light brown
Mingo.....	Brown	Purple	Black
Black Hilum Manchu.....	Brown	Purple	Black
Dunfield.....	Gray	White	Light brown
Lincoln.....	Brown	White	Black
Illini.....	Gray	White	Light brown
Viking.....	Brown	Purple	Black
Chief.....	Gray	Purple	Imperfect black

^a Arranged according to maturity. ^b Brown spot at end of hilum.



Lincoln soybeans just before harvest. Altho these beans are leaning slightly, the Lincoln variety usually stands well and combines easily. Richland is the only soybean that exceeds Lincoln in lodging resistance. (Fig. 2)

Origin and History

Lincoln originated from a natural cross between Mandarin and Manchu made in 1934 by C. M. Woodworth at the Illinois Station. In making this cross, a modification of the interplanting method suggested by G. H. Cutler of the Purdue Station¹ was followed. In every other row Mandarin, used as the female plant, was interplanted with Manchu. Alternate rows were planted to pure Manchu. This arrangement gave maximum chances for natural crossing of these two varieties.

The Mandarin seed from the 1934 crossing plot was planted in the nursery in 1935, and the natural crosses were picked out at maturity. Since the brown pubescence of Manchu is dominant to the gray pubescence of Mandarin, the hybrid plants could be detected by their brown pubescence.

The F₂ progenies were grown in 1936 and selections were made from them. In 1937 a number of the 1936 selections were grown in plant rows. From the 1937 plants further selections were made for plant rows in the 1938 nursery.

In 1937, also, the better plant rows were selected for a replicated yield test in 1938. Strain L6-685 yielded more than any other strain in the preliminary test that year and so was included in a group of early strains tested in 1939 at Holgate, Ohio, and at three locations in Illinois.

Again in 1939, L6-685 was the highest yielding strain at the four locations where it was tested. Consequently it was entered in the 1940 Uniform Group II² tests, which were conducted at nine locations in Ohio, Indiana, Illinois, and Iowa. That year it was exceeded in yield only by a sister selection, L6-12.

The following year (1941) L6-685 exceeded all other strains in the Uniform Group II tests, as well as in the Ohio variety trials and the Iowa Elite tests. In 1942 it again ranked first in Group II, and also in Group III, in which it was entered for the first time.

In the spring of 1943 a conference of state and federal soybean workers, meeting at the U. S. Regional Soybean Laboratory, decided to call the new variety "Lincoln." In 1943 Lincoln ranked first in yield

¹ CUTLER, G. H. A simple method of making soybean hybrids. Jour. Amer. Soc. Agron. **26**, 252-254. 1934.

² The U. S. Regional Soybean Laboratory, in cooperation with state experiment stations, has sponsored a program of cooperative Uniform Soybean tests. In these tests the strains are divided according to *maturity* into nine groups, designated as 0, I, II, III, IV, V, VI, VII, VIII. Group II comprises strains that are between Earlyana and Mukden in maturity, and Group III includes strains maturing between Mukden and Patoka.

in Group II but was exceeded in Group III by Chief and C56. In 1944 it ranked first in both Group II and Group III. Table 1 shows comparable yields of L6-685 and other strains for each year, 1938 to 1944.

All seed used since 1939 traces back to the best 1938 plant row, which was chosen for increase to carry on the line. Plants in this row seemed so uniform that no further selection was made.

Altho the original cross was made in Illinois and the selection work and early testing were also done there, much of the later testing and increasing of seed has been done elsewhere. Seed increase was started in 1941 at Columbus, Ohio, and was greatly expanded in 1942 in Iowa, Illinois, Indiana, and Ohio. In 1943 Nebraska and Missouri also grew seed increases. That year all seed production was controlled by the state experiment stations, but sale of the 1944 crop was unrestricted except for a general agreement to keep prices at reasonable levels.

Had it not been for the Uniform Group tests, conducted by the Regional Soybean Laboratory in cooperation with state experiment stations, Lincoln would not be in the hands of producers now. Lincoln is the first soybean variety to be increased and released cooperatively and simultaneously by several states, and it is hoped that this procedure may prove to be a pattern for future development. Many test plots are in the fields of farmer cooperators, and a good share of the credit for evaluating this new variety goes to these men who have made this testing possible.

How Lincoln Compares With Other Varieties

Since Lincoln has been so extensively tested in the Uniform Group tests, as well as in numerous state soybean tests, more comparative data are available for this variety than for most new strains. Performance of Lincoln in the Uniform Group II tests during five years

Table 1.—Yields of Eight Soybean Varieties in the Uniform Group II Tests, 1940-1944, and in Preliminary Tests in 1938 and 1939
(Bushels per acre: figures in parentheses indicate number of tests)

Variety	1938 (1)	1939 (3)	1940 (9)	1941 (11)	1942 (13)	1943 (18)	1944 (16)
Lincoln (L6-685).....	39.7	51.4	28.4	33.1	40.4	33.6	34.0
Mingo.....	....	38.7	26.0	28.6	33.9	30.3	30.6
Illini.....	33.9	44.4	25.4	28.4	33.4	30.0	31.7
Dunfield.....	27.3	39.4	23.1	27.0	32.8	28.7	28.5
Mukden.....	37.4	41.2	21.2	25.1	31.8	29.5	29.1
Richland.....	35.6	36.8	23.3	23.0	31.0	28.5	27.8
Earlyana.....	....	....	20.5	23.2	31.4	28.5	26.7
Wisconsin Manchu 3.....	33.3	33.2	19.5	23.4	30.4	25.8	27.4

and in the Uniform Group III tests for three years is summarized in Tables 1 to 5.

The Group II tests of midseason and early varieties have been conducted in the northern and central sections of Iowa, Illinois, and Indiana, northwestern Ohio, the northeast section of Nebraska, and the southern parts of Wisconsin and Michigan. These varieties have also been tested in New Jersey.

Lincoln's superiority in yield of seed over other Group II varieties is shown by Table 2, in which varieties are arranged according to yield. Producing 17 percent more beans per acre than the average of the widely grown Dunfield and Illini varieties, Lincoln has ranked first at all locations except Cherokee and Kanawha, Iowa, where it ranked second.

Lincoln has also excelled in seed quality, percentage of oil, and

Table 2.—Yields of Eight Soybean Varieties in the Uniform Group II Tests, 1940-1944
(Bushels per acre)

Variety	Average of 65 tests	Holgate, Ohio 1940-1944	Michigan			Indiana			Illinois	
			Dearborn 1941-1943	Lansing 1943-1944	LaGrange 1942-1944	Bluffton 1940-1943	LaFayette 1940-1944	Wau-tah 1940-1944	Mt. Morris 1942-1944	Dwight 1940-1944
Lincoln.....	34.1	27.1	36.7	27.8	28.0	39.3	44.9	27.0	20.0	33.9
Mingo.....	30.1	24.1	30.0	24.2	25.1	33.2	38.6	24.2	18.3	27.8
Illini.....	29.9	22.8	35.3	23.3	25.6	34.0	37.8	25.0	18.1	29.8
Dunfield.....	28.2	21.6	24.9	20.0	23.7	30.8	33.6	23.6	17.5	27.9
Mukden.....	27.5	20.4	29.6	23.1	24.0	30.9	37.2	22.5	17.0	26.8
Richland.....	27.0	21.1	22.8	18.8	21.8	29.5	32.3	21.4	16.0	26.6
Earlyana.....	26.2	21.7	30.0	20.8	21.3	29.1	30.9	22.5	17.8	24.7
Wisconsin Manchu 3	25.7	21.2	27.5	21.6	22.3	26.9	31.4	19.1	17.2	24.8
* Average.....	28.6	22.5	29.6	22.5	24.0	31.7	35.8	23.2	17.7	27.8
Percent Lincoln was above Illini-Dunfield average	17.4	22.1	21.9	28.4	13.6	21.3	25.8	11.1	12.4	17.5
Illinois (continued)										
Variety	Urbana 1940-1944	Stonington 1940-1941	Clayton 1940-1941	Madison, Wis. 1943-1944	Hudson 1942-1944	Ames 1942-1944	Kanawha 1940-1944	Cherokee 1942-1944	Norfolk, Nebr. 1943-1944	
Lincoln.....	42.0	28.3	34.0	39.4	41.3	44.1	30.4	43.5	33.8	
Mingo.....	37.1	25.8	31.1	35.1	34.8	40.3	29.5	39.9	28.3	
Illini.....	34.4	25.7	27.0	34.3	37.5	38.7	28.7	47.2	29.8	
Dunfield.....	35.4	25.7	30.9	32.9	34.9	38.8	27.2	39.0	26.5	
Mukden.....	32.9	20.5	23.1	34.2	35.7	39.6	27.4	36.7	28.0	
Richland.....	34.1	20.6	27.2	28.4	33.1	38.1	28.7	37.7	29.4	
Earlyana.....	28.6	19.4	21.2	29.4	33.4	36.8	30.6	38.0	29.7	
Wisconsin Manchu 3.....	29.6	20.7	23.7	29.9	33.2	34.5	29.0	34.7	27.1	
Average.....	34.3	23.3	27.3	33.0	35.5	38.9	28.9	39.6	29.1	
Percent Lincoln was above Illini-Dunfield average..	20.3	9.2	17.4	17.3	14.1	13.8	8.8	.9	20.1	

iodine number of the oil, and has been exceeded in lodging resistance only by Richland (Table 3). Several inches shorter than Illini, Lincoln is about the same height as Mingo, Dunfield, and Mukden. The seed is larger than that of Illini and about the same size as Mukden seed. Lincoln has required an average of 129 days to mature in these tests. This is about the same time required by Mingo, Illini, and Dunfield, and about 4 days more than needed by Mukden.

Table 3.—Summary of Agronomic and Chemical Data for Eight Soybean Varieties in the Uniform Group II Tests, 1940-1944
(Figures in parentheses indicate number of tests)

Variety	Average acre yield (65)	Lodging rating ^a (60)	Height (55)	Maturity index ^b (58)	Seed quality ^c (54)	Weight of 100 seeds (64)	Protein content ^d (69)	Oil content ^d (69)	Iodine No. of oil (69)
			<i>bushels</i>	<i>inches</i>		<i>grams</i>	<i>per cent.</i>	<i>per cent.</i>	
Lincoln.....	34.1	2.2	37	0	1.4	15.0	40.7	21.1	136
Mingo.....	30.1	2.9	36	-.6	2.0	15.7	42.9	19.9	134
Illini.....	29.9	2.9	40	+.8	1.5	13.9	40.8	20.0	134
Dunfield.....	28.2	2.8	36	+.2	1.5	15.9	40.1	20.5	130
Mukden.....	27.5	2.2	37	-3.7	1.6	14.9	43.9	19.5	130
Richland.....	27.0	1.5	31	-6.4	1.7	16.3	41.1	20.2	128
Earlyana.....	26.2	2.5	35	-10.7	2.0	14.8	43.6	20.2	132
Wisconsin Manchu 3.....	25.7	2.8	32	-7.5	2.2	16.9	42.6	20.0	133
Average.....	28.6	2.5	35.5	....	1.7	15.5	42.0	20.2	132

^a Based on a scale of 1 to 5; 1 is erect; 5 is completely lodged.

^b Days earlier (-) or later (+) than Lincoln. Lincoln required 129 days to mature.

^c Based on a scale of 1 to 5; 1 is very good; 5 is very poor.

^d Composition on a dry basis. Protein = N × 6.25.

Lincoln has also performed well farther south, in the Uniform Group III tests, for several years. These tests have been made in central and southern Indiana, central and southern Illinois, central Missouri, central Iowa, and eastern Nebraska. Lincoln has required an average of 119 days to mature in these tests — 10 days less than in the Group II tests. This difference is due to the fact that the Group III tests are made under higher temperatures. In yield, lodging resistance, seed quality, and percentage of oil Lincoln has been outstanding in the Group III tests, as it was in the Group II tests.

Lincoln has averaged 18 percent more beans per acre than the average of Illini and Dunfield in the Group III tests, the increase ranging from 29 percent at Greenfield, Indiana, to .6 percent at Lincoln, Nebraska (Table 4). In the southern parts of the Central states Lincoln is evidently just as superior to these other two midseason varieties as it is in the northern sections.

Lincoln has also outyielded Chief at every location in the Group III

Table 4.—Yields of Five Soybean Varieties in the Uniform Group III Tests, 1942-1944
(Bushels per acre)

Variety	Average of 43 tests			Indiana			Illinois			Columbia, Mo.		Ames, Iowa	Lincoln, Nebr.
	LaFayette	Greenfield	Urbana	Freeburg	Stonington	Clayton	Dwight	Columbia, Mo.	Dwight				
Lincoln.....	31.6	41.0	34.8	37.9	33.5	31.4	28.1	32.2	22.3	40.4	24.3		
Chief.....	29.2	36.9	30.5	37.5	33.6	28.7	26.1	24.8	24.4	34.2	23.5		
Patoka.....	28.4	33.8	29.0	39.1	34.6	25.2	25.9	23.4	23.4	30.5	19.8		
Dunfield.....	26.9	30.5	26.6	35.8	27.5	28.8	27.0	27.3	19.9	37.6	23.6		
Illini.....	26.4	36.8	27.2	30.6	24.8	30.9	22.3	29.1	17.5	35.1	24.7		
Average.....	28.5	35.8	29.5	36.2	30.8	29.0	25.9	27.5	21.5	35.6	23.2		
Percent Lincoln was above Illini-Dunfield average.....	18.6	21.8	29.4	14.2	28.1	5.2	14.0	14.2	19.3	11.1	.6		

Table 5.—Summary of Agronomic and Chemical Data for Five Soybean Varieties in the Uniform Group III Tests, 1942-1944
 (Figures in parentheses indicate number of tests)

Variety	Average acre yield (43)	Lodging rating ^a (42)	Height (41)	Maturity index ^b (31)	Seed quality ^c (39)	Weight of 100 seeds (42)	Protein content ^d (45)	Oil content ^d (45)	Iodine No. of oil (45)
			<i>bushels</i>	<i>inches</i>		<i>grams</i>	<i>per cent.</i>	<i>per cent.</i>	
Lincoln.....	31.6	2.2	37	0	1.6	14.1	39.9	21.7	135
Chief.....	29.2	2.8	46	+7.4	1.8	12.2	39.9	20.7	133
Patoka.....	28.4	2.3	36	+8.8	1.7	17.2	42.4	20.6	133
Dunfield.....	26.9	2.8	37	- .5	1.8	14.5	38.7	21.6	130
Illini.....	26.4	3.1	41	+1.5	1.7	13.0	40.3	20.6	134
Average.....	28.5	2.6	39	.....	1.7	14.2	40.2	21.0	133

^a Based on a scale of 1 to 5: 1 is erect; 5 is completely lodged.

^b Days earlier (-) or later (+) than Lincoln. Lincoln required 119 days to mature.

^c Based on a scale of 1 to 5: 1 is very good; 5 is very poor.

^d Composition on a dry basis. Protein = N × 6.25.

tests, except Freeburg, Illinois, and Columbia, Missouri, even tho Lincoln is 7 to 8 days earlier than Chief. At Freeburg, Chief exceeded Lincoln by only a very slight margin. At Urbana, also, the difference between Lincoln and Chief was very small, altho this difference was in favor of Lincoln. Except at Freeburg, Urbana, and Columbia, Lincoln outyielded Patoka, which matures nearly 9 days later than Lincoln.

Patoka and Chief are the only two late varieties regularly grown in Group III in comparison with Lincoln. Five late varieties, however, have been compared with Lincoln in Group IV tests, which are usually farther south than the Group III tests. Lincoln has yielded slightly better than Chief, Macoupin, and Boone in these tests, and almost as well as Gibson and Patoka (Table 6).

Table 6.—Comparative Maturity and Average Yields of Seven Soybean Varieties in the Uniform Group IV Tests, 1940-1944
 (Yields are given in bushels per acre)

Variety	Maturity index ^a	Average yield	Indiana yields		Illinois yields			Yields at Columbia, Mo. 1942-1944
			Evansville 1942-1944	Wheatland 1942-1944	Edgewood 1943-1944	Alhambra 1944	Freeburg 1942-1944	
Midseason								
Lincoln.....	0	23.6	32.1	15.6	22.1	19.0	32.2	20.6
Illini.....	+ 1.5	....	26.2	....	18.4	12.4	24.0	16.2
Late								
Gibson.....	+10.0	24.6	35.2	15.4	19.2	25.0	30.5	22.5
Patoka.....	+ 7.4	24.0	31.8	18.5	17.0	20.8	33.8	22.2
Chief.....	+ 7.4	23.5	31.8	18.2	19.2	19.8	32.1	19.9
Macoupin.....	+ 9.5	22.2	29.7	15.3	19.2	19.1	27.7	22.0
Boone.....	+11.6	22.2	28.3	14.5	18.1	22.0	24.9	25.3

^a Days earlier (-) or later (+) than Lincoln.

Table 7.—Percent of Pods Containing One, Two, Three, or Four Seeds, and Percent of Abortive Seed: Six Soybean Varieties, 1943-1944

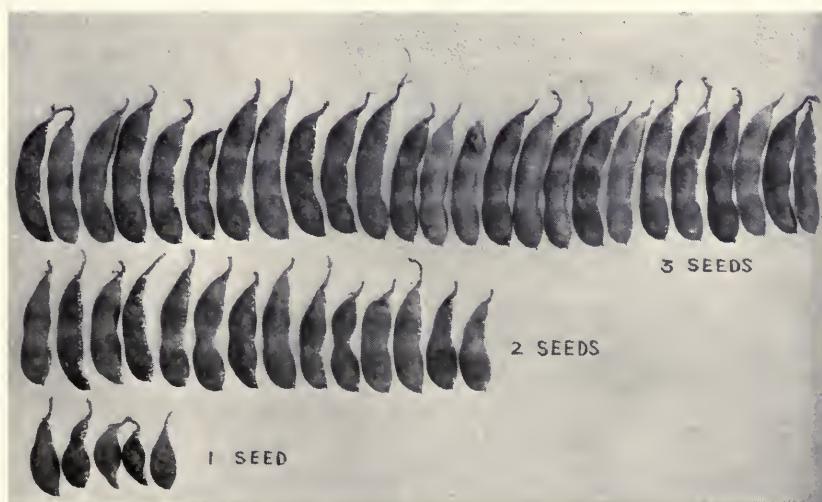
Variety	1 seed	2 seeds	3 seeds	4 seeds	Abortive seed
Lincoln.....	4.0	24.8	70.7	.5	14.8
Illini.....	1.9	23.8	73.7	.6	16.9
Richland.....	11.6	71.0	17.4	..	8.7
Mukden.....	3.8	31.2	64.9	.1	17.9
Chief.....	4.3	30.2	65.3	.2	17.4
Patoka.....	7.6	44.0	48.4	..	19.3

A three-seeded type, Lincoln has been superior in seed yield partly because of the high number of seeds per pod and the low percentage of undeveloped, or abortive, seed (Table 7).

Lincoln Performs Well Over Wide Area

Lincoln will grow successfully over a wider area than any other midseason variety released to date. It does well, as a rule, wherever Illini, Dunfield, Mukden, Mingo, Mandell, and Scioto have been successfully grown. It should largely replace these varieties, as well as others, in these areas.

Lincoln is recommended generally for planting throughout Ohio, ex-



Three-seeded pods predominate on Lincoln plants and partly account for Lincoln's high yields. The quality of the seed is also high. These one-, two-, and three-seeded pods were from one Lincoln plant. (Fig. 3)

cept possibly in the northeastern part, where earlier maturing varieties should be grown. In Indiana it is best adapted to the central section. In northern Indiana and Illinois it should be used only for early planting. In the southern parts of these states and in areas of similar climate, it is best used for medium-late or late planting. When an early-maturing variety is desired in these more southern areas, Lincoln can be recommended as much higher yielding than other early strains.

Lincoln is also well suited to northern Missouri, the southern two-thirds of Iowa, and the southeastern section of Nebraska. How well it will perform in other states has not been determined.

Occurrence of Black Seeds

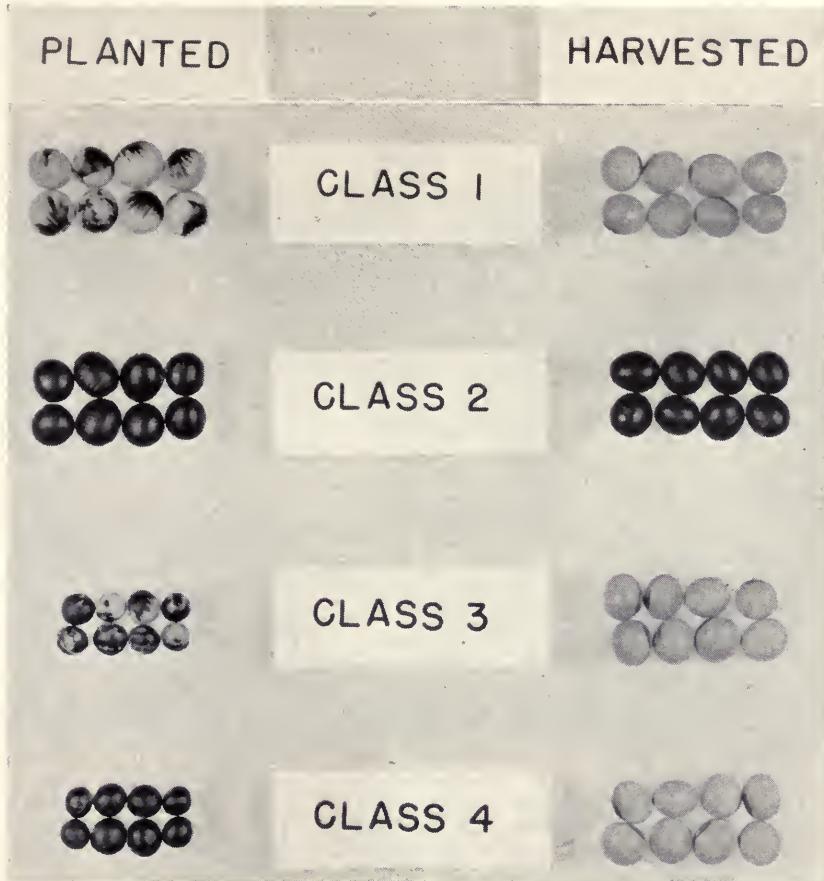
A few black seeds have been observed in bulk lots of Lincoln. These seeds breed true to the solid black color, but in all other respects, such as habit of growth, maturity, and height, the plants are typical Lincoln. Fig. 4 shows the breeding behavior of several types of abnormal seed found in Lincoln soybeans.

Black seeds are believed to result from a germ-plasm change, or mutation, which permits the black pigment in the hilum, or seed scar, to be spread over the whole seed. (The genetic explanation is that the gene i^h , restricting pigment to the hilum, has mutated to i , permitting the pigment to spread over the whole seed coat.) Similar changes have been observed in other varieties. The mutation may recur in a variety at any time.

By not planting the black seed, one can reduce the percentage of black beans in the next crop. It is impossible, however, to get rid of all black beans in this way, for some beans carry the character even tho they look like typical Lincoln seeds. Some of the plants grown from what appear to be typical beans will therefore bear black beans.

Black beans can be entirely eliminated in the following way: Select a few hundred typical Lincoln plants and plant the seed of each in a separate row. Examine all plants of each row and discard rows which show any black beans. Harvest the beans from plants breeding true to the Lincoln type and thresh them together. A lot of seed obtained in this way should not contain any blacks except thru mixture with other strains or because of another mutation to black.

Some black-mottled beans (Classes 1 and 3, Fig. 4) have also been found in Lincoln. These beans vary in the amount of black on their sides and ends. In extreme cases the seed is entirely black except for



Breeding behavior of several types of off-colored seeds found in Lincoln beans. With care in planting and selecting the seed plants, black beans can be worked out. Type of mottling shown here seems to result from faulty nutrition caused by weather, soil, or disease. (Photograph shows beans reduced slightly from natural size.) (Fig. 4)

a tiny spot of yellow. When any of this seed is planted, the resulting crop is typically Lincoln. This type of mottling is not inherited, but seems to result from nutritional difficulties caused by weather, soil, or disease. Altho even a few mottled beans mar the appearance of a lot of seed, it is not worth while to remove them, since they are not considered a genetic mixture.



Lincoln beans mature slightly earlier than Illini and 7 or 8 days earlier than Chief. In this Urbana field in 1946, the Lincoln plants were already turning yellow on September 9, while the other two varieties were still green. Lincoln plants were standing erect; Chief and Illini were both lodging. (Fig. 5)

Summary and Conclusions

A brief statement of the main characteristics of the Lincoln soybean and its adaptation and advantages is given on the next page.

LINCOLN is an outstanding midseason variety of soybean developed by the Illinois Agricultural Experiment Station in cooperation with the U. S. Regional Soybean Laboratory and other state experiment stations.

In **average yield**, during a five-year period, Lincoln has exceeded Mingo, Dunfield, and Illini by 16 percent. At the same time, it has averaged somewhat higher in **oil content** than these three varieties. In **lodging resistance**, it is about the same as Mukden and Mandell and is exceeded only by Richland.

Lincoln has averaged slightly higher in **seed quality** than any other commonly grown variety. The seed is about the same size as that of Mukden; it is somewhat larger than that of Illini and somewhat smaller than that of Dunfield.

About the same **height** as Mingo, Mukden, and Dunfield, Lincoln is several inches shorter than Illini. Lincoln **matures** about the same time as Mingo, Dunfield, and Illini and slightly later than Mukden.

Lincoln is **adapted** to an area which produces three-quarters of the total soybean crop of the United States. The use of Lincoln on many of the farms in this area will be an advantage to both farmers and processors.

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